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OPTICAL QUANTUM GENERATOR MADE OF CRYSTALLINE CdS WITH EXCITATION BY FAST ELECTRONS

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As has already been reported,[1,2] the excitation of free carriers in the bands of a semiconductor by irradiating it with a beam of fast electrons is one of the methods of making an optical quantum generator (OKG) in the visible and infrared regions.

The first experiments performed in this direction were reported in Ref. 3. However, the limited power of the beam and the insufficiently high quality of the semiconducting material did not allow one to obtain a negative temperature state in these experiments.

Recombination radiation from CdTe which had been excited by a beam of electrons from a Van de Graff generator was observed previously in work by V. S. Vavilov, V. D. Egorov, E. L. Nolle, and S. I. Vintovkin.[4]

In this article further experiments are reported on obtaining stimulated radiation and the creation of an OKG in a semiconductor by electron pumping.

A single crystal of CdS, grown by E. A. Konorov measuring 3 x 2 x 1.5 mm was soldered by means of Woods metal onto a cold copper probe in the vacuum chamber of a cryostat which was then filled with liquid He.

The edge faces of the crystal had dimensions of 2 x 1.5 mm and were parallel and carefully polished. A beam of electrons from a (Pierce ?) gun having a duration of 2.5 μsec and a repetition rate of several tens of cycles was admitted into a cylindrical resonator, in which E_{010} standing waves were excited. In the electric field of the resonator the electron beam was grouped in phase and accelerated to an energy on the order of 200 kev. The energy of the electrons was limited to the stated value, in order not to introduce radiation defects into the crystal lattice.[5] After acceleration in the resonator the electron beam was passed through a window sealed with aluminum foil 15 μ thick, admitted into a cryostat, and fell on the 2 x 3 mm face of the crystal. The current density of the electrons was measured by a Faraday cylinder in a separate experiment and the power was changed from 0 to 1 A/cm^2 by means of changing the current in the heater of the injector.

With the help of an optical system the image of one of

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the end faces of the crystal was projected onto the slit of an ISP-51 spectrograph. Spectra of the radiation from the irradiated sample were recorded on a photographic film.

The spectrum of the recombination radiation consisted of a series of broad bands, with a transition energy lying inside the forbidden bands.

At large electron beam current densities, there arose in the radiation spectrum three sharp lines with wavelengths of 5035, 4966, and 4891 Å.

The initial halfwidth of the line with a center wavelength of 4966 Å, according to measurements on the DFS-12 spectrometer, was 35 Å. At first the intensity of this line grew linearly in proportion to the increase in beam intensity and then changed suddenly by approximately two orders (Fig. 1).

Simultaneously, with the increase in intensity, there was observed a sharp decrease in the halfwidth of the line from 35 to 7 Å. (Fig. 2) The value of the threshold current is strongly dependent on the quality of the crystal.

At large current densities the intensity of the line continued to increase but its width increased somewhat. At small current densities the intensity of the radiation after removal of the excitation fell exponentially with a time constant of ~ 2 μsec. At increased currents the duration of the after-radiation was shortened and the light pulse exactly coincided in shape with the current pulse.

For estimating the relative intensity of the line the amplitude of the pulse was measured with an FEU-19 with a 4960 ± 35 Å interference filter and without it.

The pulse amplitude without the filter grows linearly with increasing current. At small values of the current the radiation was completely absorbed by the filter.

It follows from this estimate that the intensity of the stimulated radiation at maximum current densities was comparable with the summed spontaneous intensity.

In conclusion, the authors consider it their duty to express their thanks to V. S. Vavilov for a series of valuable suggestions and for constant interest in the work; to Yu. N. Popov and to O. N. Krokhin for the constant and fruitful discussions on the arrangement and conduct of the experiments, and also to A. N. Mestvirishvil and N. P. Lantsov for help in the work and faultless work of the accelerator.

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FIGURE CAPTIONS

Fig. 1 The dependence of the relative intensity of the 4966 Å line on electron beam current intensity.

On the ordinate is plotted the logarithm of the ratio of the line intensity to the current density (in relative units).

Fig. 2 The dependence of the line width of the radiation in the 4966 Å line on the electron beam current intensity. 1 - i = 0.1; 2 - i = 0.2; 3 - i = 0.6 (arbitrary units).

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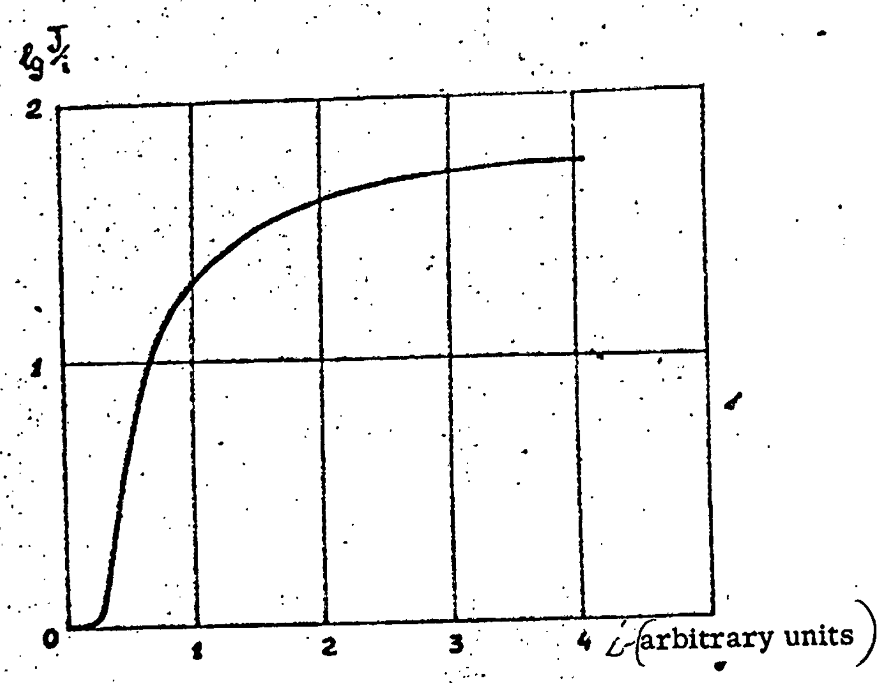

Рис. 1

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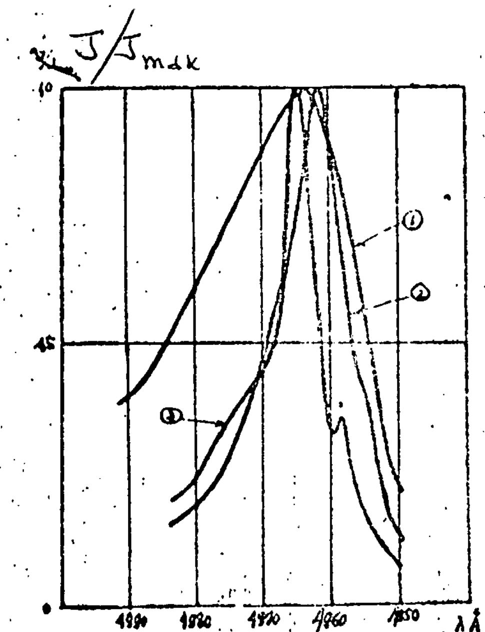

Рис. 2.